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Dynamic Vehicle Ontology Based Routing for VANETs

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Abstract

Increasing traffic load on existing transport infrastructure is resulting in bottlenecks on vehicular movement. Frequent traffic jams and accidents impose severe restrictions on passenger safety and comfort. This can affect the response time of emergency vehicles such as ambulances and fire brigades in reaching their destinations. This paper proposes a RSU based scheme that enables vehicles to evaluate existing traffic condition and dynamically adjust route information for computing optimal route to their intended destination. Each RSU estimates the congestion of all the lanes within its transmission range by considering the cumulative load of transmitted packets. This load is then utilized for estimating the vehicle density and calculating the optimal route for various ontology of vehicles by using activity file based routing protocol. The RSUs based backbone then transmits this information to the neighboring vehicles. The results of simulation represent the effectiveness and simplicity by the proposed scheme in routing vehicles through the most appropriate route and makes it more adaptive for integration with the existing approaches.

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Keywords: VANETs; Intelligent Transportation System; Shortest Path Routing; Activity Based Routing;

1. Introduction

In India, road network consists of different kind of transportation like public and private transportation. With the increase in population, the number of cars and other private vehicles are also growing at high rate on the road. So it

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provides bountiful challenge for traffic regulatory authority to manage large traffic. Severe traffic conditions may cause loss of life by means of accidents and associated threats imposes great challenge to general public. The heterogeneous type of traffic on the roads also impact vehicular movement that causes abnormal situation due to which there are lot of traffic jams and congestion on the roads. This results in long vehicular queues which cause a lot of fuel consumption and pollution by emission of CO_2.Vehicle count increase by 10.5 percent during the duration of 2002 to 2012. For the duration of 2013, the number of road calamities was 4, 86,476 as a result of which the count of deaths were 1, 37,572 and injury of 4, 94,893 persons in India[1]. Thus there is a critical need for an Intelligent Transport System (ITS) which helps to provide optimum route for vehicles to their destination and thereby reducing the traveling cost on account of wastage of time on traffic jams and congestion.

Vehicles are equipped with inbuilt sensor units which are capable of sensing and communicating with each other and result in ad-hoc communication network. The resulting network is called Vehicular Ad-hoc Network (VANETs). VANETs is a subset of Mobile Ad-hoc Network (MANETs) which allows moving vehicles to wireless communicate with each other without requiring any central access point. VANETs basically uses Dedicated Short Range Communication (DSRC). In VANETs vehicles can communicate with other vehicles and also with roadside infrastructure by the means of wireless access in vehicular environment (WAVE). Vehicle to Vehicle (V2V) communication occur using onboard units (OBUs) and Vehicle to Infrastructure (V2I) communication occur with the help of OBUs to roadside units (RSUs)[2]. VANETs possess characteristics[3] such as high mobility, frequent change in topology, no power constraints, sparse and dense node density, range between 250m to 900m, expensive infrastructure, weak multi-hop routing, regular change in pattern of nodes, use of inbuilt electronic units and position acquisition through Global Positioning System (GPS).

VANET applications require different sort of bandwidth and coverage area. These requirements are based on specific time and location. The various technologies used for wireless are Worldwide Interoperability for Microwave Access (WiMAX), cellular networks, satellite and Wireless Local Area Network (WLAN) can be adopted for VANET. IEEE 802.11p is generally referred to as DSRC standard. DSRC is based on 5 GHz frequency spectrum and partition the available bandwidth into seven channels having 10 MHz each[4]. The wireless communication between vehicles assist in disseminating different types of information for avoiding traffic jams, optimal path selection from source to destination, safety information for avoiding accidents etc. VANETs are also used for applications[2] such as entertainment application like video sharing, nearest hotel location, filling station etc. and safety application like collision avoidance, emergency vehicle warning, public safety etc. Traffic management and driver assistance are also possible with the help of VANETs.

Routing imposes prodigious challenge in VANETs due to characteristics such as mobility and frequent change in node density. So communication between vehicles and roadside infrastructure has become one of the most perplexing task. A lot of Research has been carried out by researchers to develop different types of protocols to support various applications in VANETs. These protocols[4] can be characterized as broadcast routing protocol, geocast routing protocol, forwarding routing protocol, cluster based routing protocol , beaconing routing protocol, position based routing protocol, delay tolerant routing protocol and ad-hoc routing protocol. Clustering protocol in VANETs require consistent speed as well as mobility to make cluster which is a difficult task for all the vehicles while ad-hoc protocols are mostly used in MANET and have been tested in VANET environment too.

Shortest path algorithm[5] is mostly required for source to destination when there is traffic jam or other calamity. To address this problem shortest path routing protocol is necessary for emergency vehicles, disaster recovery vehicles and fire brigade vehicles. These routing protocol may use roadside infrastructure to find shortest route from source to destination. Most of the proposed protocols for shortest path routing are extended with Dijkstra's and Bellman Ford algorithm. These algorithms help to find shortest path to the destined location. The main goal of these protocols is to send packets with minimum delay.

Traditional traffic light control system is based on static approach i.e. traffic light changes after fixed interval. This static behavior of traffic light sometime results in emergency vehicle having to wait relatively longer at road junction. So there is urgent need of intelligent traffic light control system which is based on VANETs and changes according to vehicles density in particular lane. It must be adaptively controlled by traffic regulatory authority and based on traffic density messages sent by RSUs which are close to intelligent traffic lights.

This paper aims to find shortest path between source and destination by considering present vehicular condition and transmission characteristic based on shortest route required by corresponding packets to travel from vehicle source and vehicle destination with the help of RSU. The paper develops an intelligent traffic light control system that reduces average waiting time on road junction.

The paper is structured as Section 2 reviews the related work, Section 3 presents the proposed network model and assumption, Section 4 presents the proposed work, Section 5 shows simulation and results and Finally, Section 6 concludes the paper.

2. Related Work

Intelligent Transport System (ITS) is one of the most challenging area of research. In the past years, academic professionals, researchers and transport engineers have proposed number of shortest routing and adaptive traffic light control system that are based on increasing vehicles rate and allow vehicles to move safely and increase the comfort of travelers.

Loulloudes et al.[6] proposed scheme that consider the changing aspects of VANETs in urban scenario and explore the influence of this scheme in the design of VANET routing protocols. They studied the various networking shapes for VANETs under different transmission and penetration ranges, using both real and realistic mobility traces. They assumed that RSU's need to be arranged for sharing information to vehicles in an urban area and studied their impact on vehicular connectivity.

Zhang et al.[7] studied the problem of tracking prevalent in VANETs and proposed two different types of solutions named as Area-Based Tracking (ABT) and Parked Vehicle-Assisted Tracking (PVAT).They also showed that ABT worked well if the delays in data transmission from source to target were small enough, and PVAT worked as an enhancement of ABT and could be used when the delays in data transmission from source to target were comparatively large.

Kumar et al.[8] reflected on problem that was based on the selection of optimal next-hop between two vehicles enroute using basic view of VANETs. After accurate estimation of the optimal number of hops, the proposed work selected the optimal set of next-hop of node which depended on speed and inter-node distance for further increasing the predictable route time.

Shenglei et al.[9] proposed a route optimization algorithm which was used to reduce the routing problem. It increase the routes life time in VANET based scenario using both OBU and RSU. They combined the proposed scheme with Ad hoc On-demand Distance Vector Routing (AODV), Location-Aided Routing (LAR) protocols for evaluating the performance. The simulation result showed that there was improvement in data transmission.

Shekar et al.[10] used Dijkstra's algorithm which was used to find out the shortest path considering non-recurring congestion which occurred due to unwanted and unpredictable incidents, thus select optimal path and utilize minimum time to the destined location. VANET based useful navigation system for ambulances was deployed through a centralized dispatch center. It helped to remove unpredictable jams and selected the shortest path to the destined location based on already stored previous data. They also used the updates from real time traffic information. However the proposed scheme based on widespread availability of metro transport system that joined all the different locations of city with dispatch center.

Panahi et al.[11] proposed system which was developed using real time condition of traffic and Geo-spatial Information System (GIS). The developed system found dynamic shortest path that was used for emergency vehicle path selection. It was based on Dijkstra algorithm to select the shortest path.

Shirani et al.[12] proposed two algorithm. The first algorithm was used to predict the weightage of different paths from source to given destination and select shortest path. The second algorithm was used to keep the traffic light green and provide absolute priority for the emergency vehicle such as ambulance based on adaptive control of traffic light.

Seethalakshmi et al.[13] selected the eligible path. It was built considering power consumption of various node, traffic capacity and number of inter nodes in the given network. To calculate the best routing, simple rules were created. These rules were based on fuzzy and rough set procedures. It was also used for calculating path vector and remove irrelevant resource and attributes. The given rules were estimated using various proactive and reactive protocols. The simulated environment used various protocols such as Destination-Sequenced Distance-Vector

(DSDV), AODV and Dynamic Source Routing (DSR). It was based on these metrics such as throughput, average end-to-end delay, total energy consumed and packet delivery ratio.

Yousef et al.[14] designed work that utilized the traffic light controllers effectively and efficiently. It managed the traffic light adaptively. The system developed new traffic infrastructure based on Wireless Sensor Network (WSN) and helped to control traffic light system adaptively.

Collins et al.[15] presented and developed TraffCon. It was unique Traffic Management System (TMS) basically used for wireless vehicular networks. It conflicted with the problem of vehicular network and developed an optimize procedure for present road density. It provided an architecture based on server-side module used for decision making. It was used for the broadcasting of various instructions to nearest vehicles.

Maslekar et al.[16] proposed system that could adaptively control traffic signal. It was based on communication between vehicles to vehicles. The proposed system reduced the queue length and average waiting time of the vehicles at the road junction. The given system was tested near the road junction and it was collision free. The proposed system was compared with a classical pre-timed system. The simulations represented the communication delay between vehicle and traffic signal. It did not make any compromise with the efficiency of proposed system.

3. Network Model and Assumption

The automation process for the proposed scheme uses a network model that includes both V2V and V2I communication. It is assumed that RSU's are placed near every road intersection where traffic lights are installed as shown in Figure 1. Each RSU counts the number of vehicles in specific lanes within its transmission range. The RSUs send this information to Traffic Regulatory Authority (TRA) which manages the timing of all the lights through a dynamic traffic light system. Then TRA sends a message that contains traffic light timing information to each traffic light junction for dynamically updating the duration of all the traffic lights. The proposed scheme utilizes the transmission information of messages collected through RSU to measure mean delay, packet delivery ratio, and number of vehicles in particular lane. Basically RSUs operates as an exchanger of message between TRA and traffic light controller.

Moreover vehicles communicate with each other for transmitting real-time information based on mean delay and other alternative routes to its destined path. Also RSUs are used as infrastructure for long distance communication and use DSRC protocol based on IEEE 802.11p. Due to relatively higher frequency of changes in vehicular density and mobility patterns, a dynamic broadcast range for vehicular transmission are considered. This provides the vehicles up-to-date information about the traffic condition in its destined route in shortest possible time so that they can react prior to the point at which there is any abnormal traffic. It also helps the vehicles to find nearest route with minimum delay by receiving message from neighboring vehicles. The mobility and activity files are generated by Simulation of Urban Mobility[17] (SUMO) Simulator and have been utilized in the proposed work to simulate semi-real time traffic scenario for urban roads based on vehicular parameters like their current coordinates, speed, trip start and trip end duration.

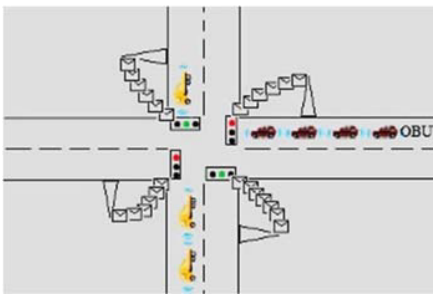

Fig. 1. RSUs installed near road junction.

4. Proposed Work

The existing protocols for providing effective vehicular movements based on vehicular adhoc networks used only mobility traces for semi real time simulation of SUMO. The proposed scheme adds activity file based information to further enhance the efficiency of system. The proposed work uses the Algorithm 1.

Algorithm 1 Route Selection Using Activity File

Input: Number of vehicles, Activity file, Mobility File, Simulation time

Assumption: RSU near each road junction

```
Begin
for each vehicle do
    Create activity table
    while each RSU near road junction do
        if (Vehicle entry exist in activity table and in RSU range) then
            Mark it as active
            For every T units of time
            Start sending message by each vehicle to RSU at particular time in table
            Find the number of vehicles sending message using Id in particular lane
            Calculate the packet delivery ratio for vehicle in particular lane
            Calculate mean delay for vehicle in particular lane
        end if
        if (Mean delay> Threshold) then
            Send message road is congested and select RSU with minimum mean delay
            Send Packet delivery ratio and mean delay to traffic regulatory authority
            Traffic regulatory authority adaptively change traffic light based on data.
        end if
    end while
end for
if vehicle out of range then
    Mark it as passive
    Break
end if
End
```

The proposed scheme uses SUMO Simulator to first create an activity file from the mobility simulator. Then a node activity helper class is built in network simulator NS-3[18] that uses the activity file created in the initial step. The requirement of V2R communication is then fulfilled by positioning RSU's at all critical road junctions and these RSU's work as data sinks for the vehicles in their transmission range. Whenever a node enters within the communication range of a RSU, it begins the process of data transfer by broadcasting packets using Constant Bit Rate (CBR) based mechanism.

The nodes receiving these packets then generate the activity information for that node by using the entries in activity table. This is done by validating whether any previous entry is already stored for that node. If no prior entry is there in the activity table, then a new entry is created corresponding to that node and its approximate end time for leaving that particular lane is also computed and stored in the table. The activity table is refreshed periodically by removing entries for vehicles who have left a particular lane or are within transmission range of some other RSU.

5. Simulation and Results

5.1. Simulation Environment and Tools used

The proposed work is simulated using network simulator NS-3 which make use of mobility and activity file generated by SUMO. Vehicle mobility is simulated using microscopic traffic simulator SUMO. The traffic simulator presents road network of urban scenario of Chandigarh city as represent in Figure 2(a). The simulation is done with same type of vehicles which enter the Chandigarh city from different entry points and deliver their packet transmission to RSU near the traffic light junctions. The movement of vehicles near the junction is represented in Figure 2(b). Instead of simulating complete urban scenario of Chandigarh only those road junctions are simulated where the degree of traffic is more. The various parameters used for simulation in the proposed work are summarized in the Table 1.

Table 1. Simulation Parameters.

Parameter	Value
Number of Vehicles	242
Number of Lanes	2
Type of Trip	Random
Acceleration Rate	$0.8 m/s^2$
Deceleration Rate	$4.5 m/s^2$
Length of Vehicle	5m
Simulation Time	300s
Max Speed	36m/s
Routing Protocol	DSDV,OLSR
MAC Protocol	802.11p
Transmission Range	300m

Fig. 2. (a) Map of Chandigarh city in SUMO; (b) Vehicles movement in SUMO environment.

5.2. Results

To evaluate the performance of Dynamic Vehicle Ontology based Routing (DVOR) which is developed by using activity file, following three performance metric have been used and compared with Destination-Sequenced Distance-Vector (DSDV) and Optimized Link State Routing (OLSR).

Packet Delivery Ratio: It is defined as the ratio of number of data packets received by target successfully to the total number of packets which are sent by sender. Figure 3 shows comparison between packet delivery ratio of DVOR, OLSR and DSDV. The result shows that DVOR protocol helps in improving packet delivery ratio as compared to OLSR and DSDV protocol because these protocols are not using any activity file. The packet delivery ratio of DVOR goes increasing with respect to time.

Mean Delay: It is defined as the average time that is being taken by data packets to arrive at target from source. Mean delay basically caused by route discovery and data queue process in data transmission. Figure 4 represents comparison between mean delay of DVOR, OLSR and DSDV. The result shows that DVOR protocol's mean delay always less than other protocol and always remain consistent with respect to various simulation time. But mean delay of other protocol changes differently with respect to various simulation time and its value is more than DVOR.

Trip Duration: It is the total amount of time which is taken by the vehicle to reach from source to destination. The trip duration of various vehicles with specific identity is represented in Figure 5. It is clear from the result that trip duration in proposed work is less as compared to traditional system. So, it minimizes waiting time and hence reduces pollution and fuel consumption.

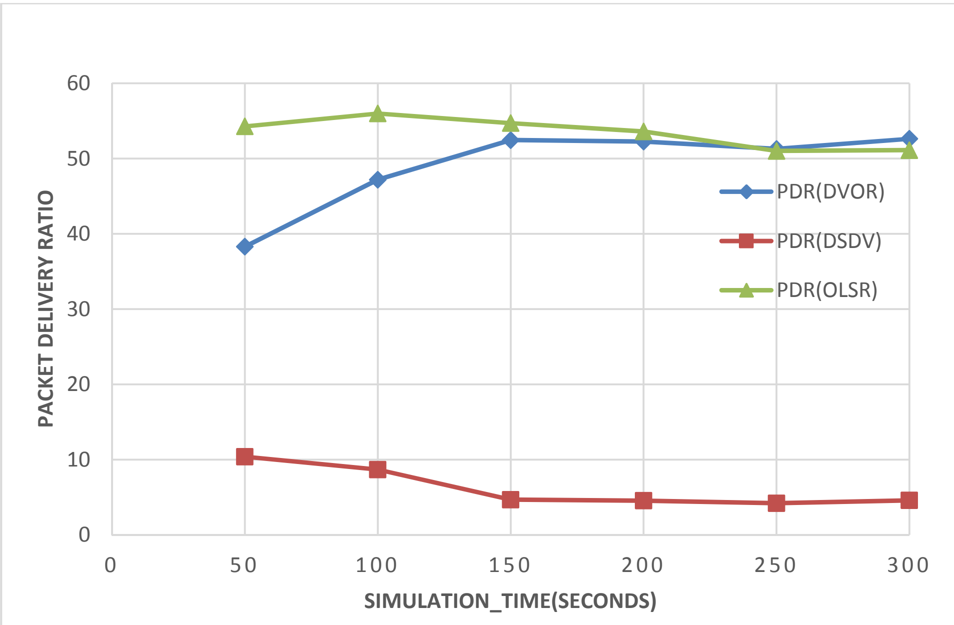

Fig. 3. Packet Delivery Ratio.

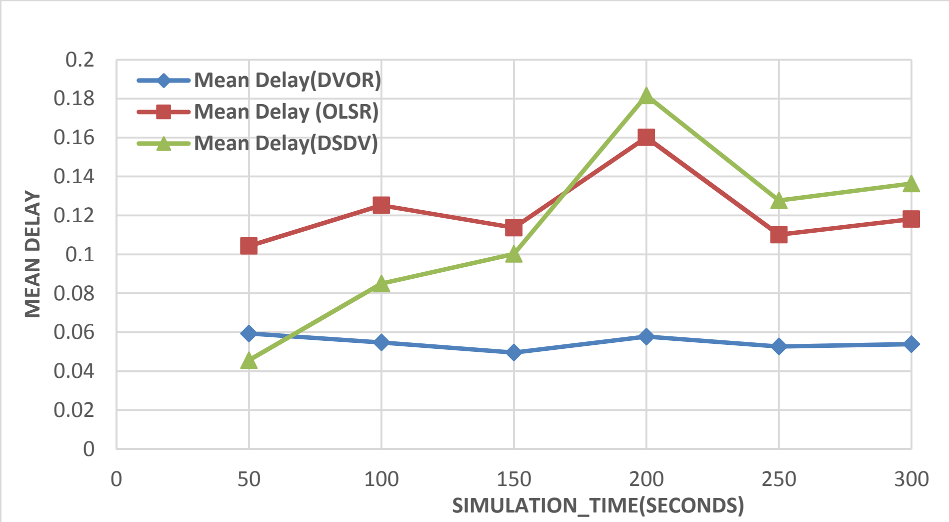

Fig. 4. Mean Delay.

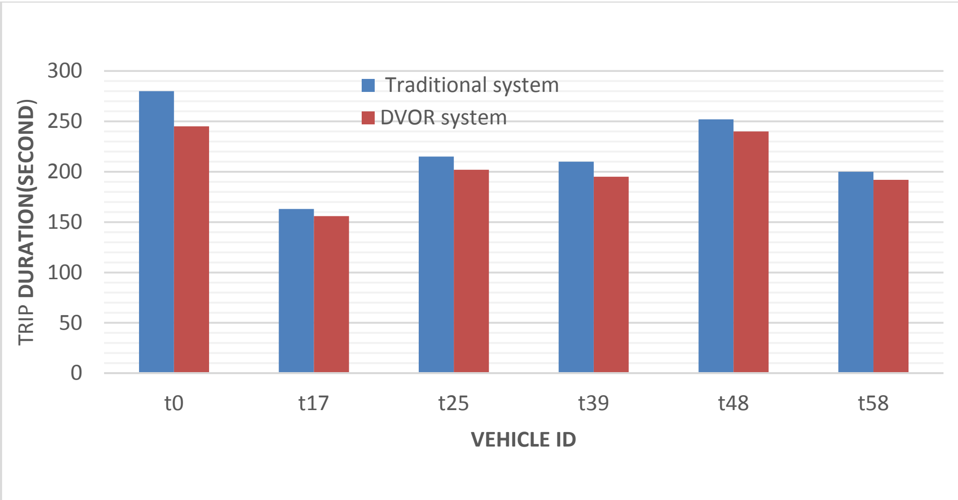

Fig. 5. Trip Duration of Vehicles.

6. Conclusion

This paper has defined dynamic vehicle ontology based routing. The proposed work aims to find shortest path routing with minimum mean delay, high packet delivery ratio and reduced waiting time for vehicles at traffic jams. The system is compared with different kind of routing protocol with same simulation parameters. The result shows that this approach is very effective as compared to other Ad-hoc protocols. The proposed technique is tested without considering any type of attacks. In future simulation of different set of attacks and their variations can be considered in order to check the existence of the proposed scheme. It may also be used for checking any malicious nodes in the intrusion detection system mechanism. The future work may also focus on Intrusion detection system.

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